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1.3 GHz Phase Averaging Reference Line

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A 1.3 GHz phase averaging reference line has been installed at Fermilab's ASTA SRF Beam Test Facilty. The reference line is composed of directional couplers and 7/8" coaxial cable. The reference line is shorted at one end of the line to provide reflected signals that are summed and phase averaged with the forward signals at each directional coupler. The phase drifts of the 7/8' cable are compensated for by the phase averaging at each coupler. A method has also been developed to minimize phase deviations caused by impedance mismatches and directivity of the directional couplers. Simulation results of the the reference line are presented along with measured results of phase drift at one of the reference line taps.

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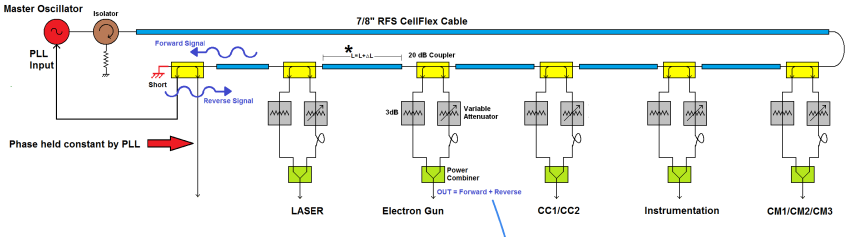

* changes in cables lengths between tap positions due to temperature changes (L = L + ΔL)

the output becomes: $\text{OUT} = A_f \cos(\omega t + \phi_f + \Delta\phi_f) + A_R \cos(\omega t + \phi_R - \Delta\phi_R)$ (Forward, Reverse)

When the phase at the shorted end of the reference line is held constant, $\Delta\phi_r = -\Delta\phi_R$

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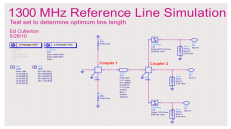
$\arg\{A_f \cos(\omega t + \phi_f + \Delta\phi_f) + A_R \cos(\omega t + \phi_R - \Delta\phi_R)\} = \arg\{A_f \cos(\omega t + \phi_f) + A_R \cos(\omega t + \phi_R)\}$

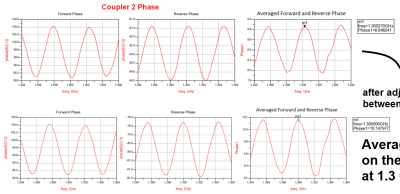
* original design concept by J. Frisch, D. Brown, and E. Cisneros

A design procedure has been developed that minimizes the phase errors between taps of the reference line by adjusting the cable lengths between couplers so that the averaged phase of the forward and reflected signals are on the peak phase ripple caused by the impedance mismatches.

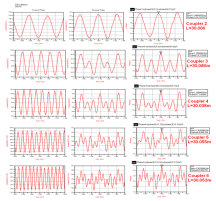
Simulations to verify design procedure



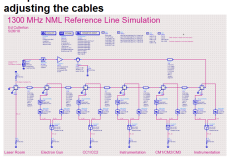
Adjustment to the cable length between the couplers so that the peak phase ripple of the averaged signals is at 1.3GHz



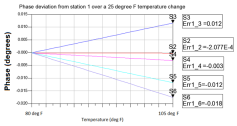
This step was repeated for each cable between the couplers



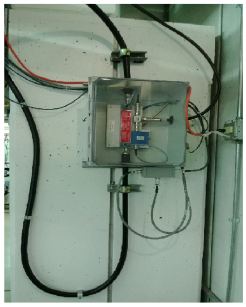
Complete reference line simulation after adjusting the cables



The electrical length of the cables between the directional couplers was swept over a length equivalent to a temperature change of 25 degrees C.

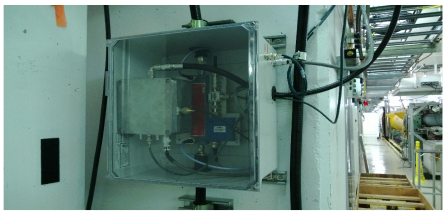


Photos of installed reference line

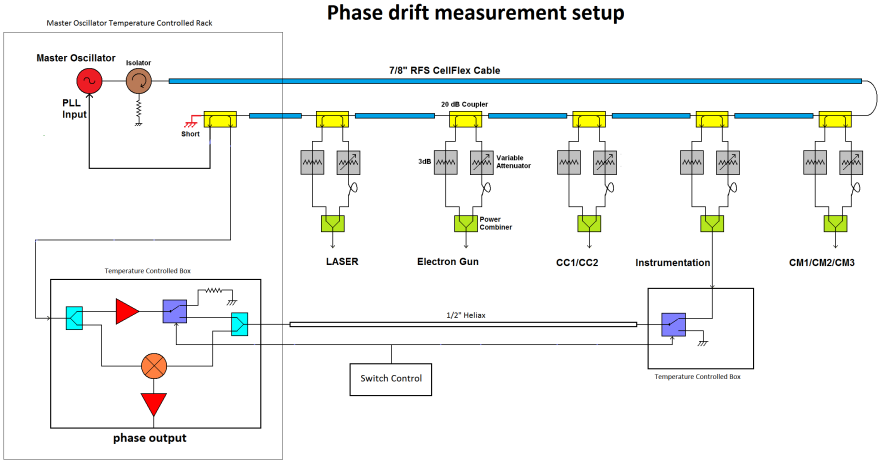


The photo on the left shows one of the taps inside a temperature controlled box. Each tap of the reference line is temperature controlled to reduce phase drift. The photo also exhibits the flexibility of the installation.

The photo on the right shows the tap with the phase drift measurement set inside the box.



Phase drift measurement setup



The phase drift of one of the taps is measured using the measurement setup shown on the left. A phase detector measures the phase difference between the phase reference at the master oscillator and the tap located at the far end of the reference line. A calibration signal is switched on periodically to measure changes in the cable that feed the phase detector.